	Aerotrain Atmospheric		Aerotrain Vacuum tube	Hyperloop Alpha Atmospheric		Hyperloop Alpha Vacuum tube	
Gas Constant	8314	R	8314	8314	R	8314	
Gas Mol Wt (air)	28.97	M	28.97	28.97	M	28.97	
Heat cap ratio (air)	1.4	k	1.4	1.4	k	1.4	
Weight of train Kg	12,000		12,000	12,000		12,000	
Bum and curve g-loading	1.50		1.50	3.00		3.00	
Max loading Kg	18,000		18,000	36,000		36,000	
Length of each cushions m	20		20	1.50		1.50	
Width of each cushion m	1		1	0.90		0.90	
Number of cushions	4		4	28.00		28	
Gap height mm	25		25	1.00		1.00	1 mm slot is extremely small
Total area m2	80		80	37.80		37.80	
% of cushion used for lifting	60%		60%	90%		90%	
Pressure cushion relative Pa	3,679		3,679	10,381		10,381	Pressure above ambient
Total gap length m	168		168	134.4		134.4	
Total gap area m2	4.2		4.2	0.1344		0.1344	
Ambient pressure atmos Pa	101,000	P2	100	101,000	P2	100	
Pressure of cushion Pa	104,679	P1	3,779	111,381	P1	10,481	
Air temp K	298	T	298	400	T	400	
Air density Kg/m2	1.224	Dn	0.044	0.970	Dn	0.091	
Speed of sound m/s	346	Ss	346	401	Ss	401	Alpha higher due hig temp
Orifice flow coeff	0.8		0.8	0.8		0.8	
Pressure increase/input	0.04		36.79	0.10		103.81	
Is it Choked? Y or N	N		Y	N		Y	Choked above press ratio 2
Incompressible velocity m/s	62.02		326.45	117.03		381.49	Only valid at low speeds

Slot exit velocity m/s	62.02	C	346.02	117.03	400.89	Mach 1
Slot vol flow m3/s	260.50		1,453.29	15.73	53.88	
Slot mass flow kg/s	318.86		64.21	15.26	4.92	
Mass flow rate Kg/s	318.856		64.213	15.260	4.919	
Inlet pressure Pa	101,000		100	101,000	100	
Inlet temp K	292.0		292.0	292.0	292.0	
Discharge pressure Pa	104,679		3,779	111,381	10,481	
Polytropic Efficiency	0.810		0.810	0.810	0.810	
Overall compression ratio	1.04		37.79	1.10	104.81	
Polytropic exponent	1.54		1.54	1.54	1.54	
density at inlet	1.20525		0.00119	1.20525	0.00119	
Average compressibility=1	1.0000		1.0000	1.0000	1.0000	
Discharge temp K	296		1,051	302	1,507	
Discharge temp C	23		778	29	1,234	
Polytropic head	3017		617850	8342	988343	
Polytropic gas power W	1,187,639		48,980,245	157,159	6,002,415	
Compressor power kW	1,188		48,980	157	6,002	
		Power ratio	41.2	Power ratio	38.2	

Multiplier of power required in vacuum vs atmosperic

Alpha exit speed		
Mass flow kg/s	0.2	
Vol flow m3/s	2.19	
Gap area m2	0.1344	
Exit speed m/s	16.30	This is Alpha's flow

The purpose of this sheet is to show how much the compressor power must increase
when an air cushion vehicle runs in a vacuum tube with 1/1000th of an atmoshere.

The first column is matching the achieved performance of the French Aerotrain
The cushion sizes are estimated, then the gap width is adjusted to get about 1,100 kW for the lift compressors
The gap is 90mm, this is required for stabilty and protection against skirt rubbing
The big gap allows the airflow, and cushion pressure to respond to ride height
The flow velocity is calculated using an incompressible orifice flow formula

The second column looks at the same configuration, but running in a partial vacuum of 100 Pa
The compressor power increases by a factor of 43:1 to 46 mW

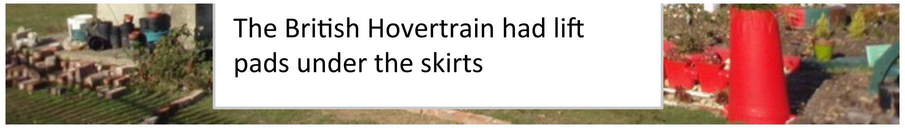
The third column is Hyperloop Alpha
The gap height of 1mm is used
When running in the vacuum tube, the power increase is a factor of 38:1, to 6 mW

All the compressor calcs were adapted from
www.elsevierdirect.com 06_Compressors.xls Power-Centrifugal.
This compressor calculator matches Hyperloop Alpha's compressors. Polytropic efficiency may need to be adjusted.

Incompressible flow thru orifice, only applies for low pressure ratios
Q= C A2(2(P1-P2)/Dn)^.5
but V=Q/A2
V=C(2(P1-P2)/Dn)^.5

Choked flow theory, state that for pressure ratios above about 2, the flow velocity will be Mach 1.
The Kantrowitz limit says that once Mach 1 is achieved, the speed will not increase regardless of lowering the outlet pressure.

The French Aerotrain achieved a remarkable 430 km/h in 1974



The British Hovertrain had lift pads under the skirts

There are several interesting ground-effect projects. They would not work in a vacuum